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LESSONS LEARNED AS A NOVICE RESEARCHER: A PILOT STUDY IN MATHEMATICS EDUCATION

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The lessons we learn in life are often catalyzed by events or happenings that we experience and that subsequently change us in some way. Life as a graduate student is replete with diverse experiences that mold and shape one's outlook on teaching, learning, and disciplined inquiry. As a doctoral candidate, my role as a novice researcher is increasingly budding with growth and my responsibilities to design and conduct research have engendered some important lessons. Often confined to private or classroom conversations with gradate students and faculty members, the lessons I have learned as a novice researcher seem worth sharing to a larger audience.

To set the context for this discussion, in Fall 2010 I carried out an individual research project that served as a pilot study for my dissertation. This research involved high school students' use of computer algebra systems (CAS)—mathematics technology that affords the creation and manipulation of graphical, numeric, and symbolic representations. Through task-based interviews with pairs of students, I investigated the nature of the translations and connections students made between representations, important components of representational fluency and students' conceptual understanding of mathematics.

The lessons I discuss below include: developing relationships and refining my role as a participant observer, the utility of writing an HSIRB protocol, and the contention that daily writing and reading are importance research practices. I also discuss the importance of being involved in a community of well-intentioned critics, and communicating research as a chain of reasoning.

Developing Relationships and Refining My Role as a Participant Observer

Some forms of research, such as a textbook analysis for example, do not require developing relationships with other people. On the other hand, my research involved interviewing high school students and thus required not only selecting an appropriate school site to conduct the research, but a principal, teacher, and students, who were interested in participating. Several semesters prior to conducting the pilot study of focus, I communicated my research interests to colleagues who had connections with teachers at local schools. I was fortunate to become acquainted with and to begin developing a professional

relationship with a particular teacher who supported my inquiry into students' thinking about mathematics in technology-rich settings.

What is the goal of observing? During scheduled observations of the classroom, I learned that it was important to both have a goal before observing and to reflect on the experience afterwards. For instance, for some of the first classroom visits, I was interested in observing how CAS technology was positioned in the classroom. How were students using the technology? Did the teacher, textbook, or lesson content seem to influence students' experiences in learning mathematics with CAS technology? Were symbolic, graphical, or numeric representations more prominent? Were students encouraged to reflect on the use of CAS technology with multiple representations? By asking questions and reflecting on what I observed unfold during instruction, some of the complexities of classroom became more clear.

How should observations be documented? As an artifact of these practices over time, I realized the importance of developing refined methods of taking field notes and also gained a better sense of students' experiences that seemed significant in a technology-enriched mathematics classroom. Before conducing the pilot research, I had informal research questions in mind, and developed and tested various protocols to be used during observations, which helped me to focus on what I was really interested in—students' representational fluency in CAS environments. In addition to documenting my experiences in personal field notes, I had regular conversations about my experiences with the classroom teacher, and also with an advisor. These conversations pushed my thinking, sometimes confirming and sometimes challenging my interpretations of classroom practice.

What is an appropriate role to assume in the classroom? Many of my observations occurred prior to conducting the pilot research so it allowed time to reflect on my role in the classroom. I found it useful to ask myself questions that had various trade offs. For instance, what are the advantages to walking around the room and asking students questions as opposed to sitting silently in the back of the classroom? Should I observe one student or group of students who seem to be more active in using their CAS technology during class time or should I observe several students or groups of students to capture a more diverse picture of students' activity? With the permission of the teacher, I found it more engaging and was able to have richer experiences by asking select students questions about how they were using their CAS. I usually focused on a few students who were more active in using their CAS technology because it gave me more to observe and to reflect on with respect to my evolving research questions.

How are relationships formed with key players? Finally, it was important for me *to* kindle a professional relationship with the teacher so as to

develop a sense of trust and comfort with her and her students. Through my experiences in observing the classroom, I not only developed relationships with the teacher, but I became a familiar face to the students. In particular, the students became accustomed to me being in the classroom, and were comfortable answering questions, and letting me watch how they were using their CAS technology. The principal was also a key player in conducting research at this school site because schools and districts have their own regulations about the conduct of research, not too dissimilar to the regulations set out by HSIRB at Western (discussed in the next section). Thus, a necessary first step in conducting research with human subjects was clear communication with the principal and teacher at the select school site. Without it, my research would not have been possible.

HSIRB Protocol is a Worthwhile "Hurdle"

My research involved interviewing students, so it was necessary to complete an HSIRB protocol. This is somewhat of a lengthy process and thus was one of the first tasks I was charged with early on in my project. Embarking on writing an HSIRB proposal for the first time seemed like a daunting task. I had previously attended a training session supported by the Graduate College, but at that time I was not conducting my own research so it was hard to engage in the presentation. However, I should mention that I did enjoy the opportunity to meet Vicki Janson, a former research compliance coordinator at WMU. I had also completed the necessary training, but again, it was not "real" to me at the time because I had yet to conduct research with human subjects.

How do you work under strict timelines? I had a strict timeline in completing the HSIRB for my pilot research, and needed to have a clear conceptualization of my study in the first weeks of the semester. I created a separate "HSIRB" folder that contained drafts of my own protocol, and other accepted protocols (including an example of one that had been rejected and subsequently revised and accepted). Having access to exemplar protocols was paramount in crafting my own successful protocol.

In crafting my protocol, I needed to keep in mind both what my own restrictions and needs were, but also the restrictions and needs of the participating teacher and her students. Due to the nature of the school site, I conducted the interviews during class time so it was necessary to coordinate schedules. The teacher and I communicated via email and phone for more general planning purpose, and in person regarding the intricate details of recruiting participants and scheduling the interviews.

How do you refine your research ideas? My advisor explained that one should complete an HSIRB when a research study that involves human subjects is mostly (or totally) conceptualized—this proved to be easier said than

done. In particular, I found it most difficult to refine my ideas into something that was researchable in the timeline of a semester. I was simultaneously trying to manage and toggle between the pressure of both short-term goals of the semester's pilot study, and future research that would eventually inform my dissertation research. The HSIRB requirement to clearly articulate the design and plan for my research study forced me to put into words the study that I had conceptualized. For example, I needed to articulate select research questions, but also to provide justifications for the design I had chosen. Why fewer participants in a qualitative design rather than a greater number of participants in a quantitative or mixed methods design? Why interview students in pair rather than individually? What tasks would I use during the interviews and what questioning techniques would I employ?

I decided to interview three pairs of students for an hour each with researcher designed tasks and probing questions that were modeled after related research studies on students' use of technology and multiple representations. Following Huntley, Marcus, Kahan, and Miller (2007), it was my contention that interviewing students in pairs would generate richer data and promote student-student and student-technology interactions, allowing the researcher to be less invasive in students' experiences with the specifically designed tasks. I also decided to design the tasks and probing questions so that students would make use of multiple representations. For example, they might start out by solving a task in a given symbolic representation, then need to draw on a graph or a written context to make sense of that result. As the goal of my research was to uncover the nature of students understanding of the connections between representations I decided it was fitting to encourage students to use multiple representations if they didn't consider this option on their own.

How do you craft a protocol that is specific but allows for some flexibility? After submitting my protocol, but before conducing the study, I decided that I needed to make changes to the tasks and questions that I had designed. In email conversations with the compliance coordinator, I was able to get the changes approved in a timely manner, but it was also suggested that I use different wording in future HSIRB protocols. For example, instead of saying "these tasks will be used" and "these questions will be asked" I could have used language such as "tasks similar to the ones included here will be used" and "questions like the ones included here will be asked" so as to safeguard against needing to make changes between the time the protocol is submitted and the study is conducted.

In the end, my HSIRB protocol served as a well-organized record of my plan for research which ultimately facilitated carrying out the pilot study. I had hands on experiences in keeping efficient and realistic timelines, and cannot stress enough the importance of clearly communicating these plans with all involved (in this case, the school principal, teacher, and students).

Reading and Writing are Central Practices of Research

In advice to aspiring researchers, Boaler, Ball and Even (2003) contend that reading and writing are two central practices of research. In the midst of classroom visits and completing the HSIRB protocol in the first weeks of my pilot research, I found the practices of reading and writing to be extremely beneficial to my growth as a researcher.

Reading is an important practice of research. Throughout the course of the semester, my readings included both those geared toward the research process in general, and those more specific to my own research interests. For example, Alan Schoenfeld (2007, 2010) offers accounts of method and theory that are both significant aspects of research in mathematics education (and to other fields as well). These readings helped me understand some of the important decisions that a researcher needs to make in designing quality research. On that note, I found Marti Simon's (2004) description of quality research in mathematics education to be helpful in crafting my pilot study because it gave me some criteria to latch on to in conducting and communicating about my research. In particular, Simon stresses the importance of justifying the design and conduct of a study, and portraying the research as a logical and coherent chain of reasoning.

With a clear focus on research design, my consumption of literature had a new and lively purpose. I learned to recognize and incorporate important jargon and constructs specific to the field of mathematics education, how to identify and include a clearly delineated research framework, and the importance of stating clear research questions as a major part of a chain of reasoning.

*Writing is an important practice of doing research***.** While occupied with reading, I was engaged in regular writing. The assignments of the research course I was taking included a research interests paper, a literature review, a research design and methods paper, and a final report that included my results and a discussion of implications. In addition to these papers, I kept updated entries in an EndNote library of all the readings I was doing and included helpful key words to make searching the database more efficient. I also wrote in both electronic and paper journals, and kept organized records of all research experiences such as field notes from classroom observations and notes and memos of coding processes. By keeping myself in the regular habit of writing, I found it easier to organize my thoughts and to keep track of the things I was learning throughout the research process.

*Reading and writing are creative processes***.** By engaging in the process of reading and writing on a daily basis, I also came to understand how creative energy is needed before, during, and after designing and conducting research. Becoming a specialist in a particular domain or field requires that

one has mastered the literature and is an expert in that area. In this light, I found it particularly beneficial to use previously established criteria to set goals for my own research. For instance, Boote and Beile (2005) provide a clearly delineated framework with criteria that can be used in judging the quality of a literature review. In my experience I was better equipped to craft quality research by regularly engaging in the practices of reading and writing, while attending to quality criteria established by experts.

On a final note for this learning experience, I remember asking a former doctoral candidate in mathematics education what advice she had or what she might do differently throughout the research process. She remarked that she regretted not spending more time reading throughout the research process because reading helps to exemplify well crafted and communicated research. In looking ahead to the writing my dissertation, I will keep in mind the important practice of reading, for it will not only keep me abreast of contemporary research, but will also inform my communication of research.

Surrounded by a Cadre of Well-Intentioned Skeptics

Learning can be perceived as a practice of transforming one's participation in a community of practice from peripheral membership to core membership (Wenger, 1998). In a research community, this participation includes consuming and engaging in critiques of others' research. While designing and conducting my pilot research, I participated in a capstone course with several other doctoral students and a faculty member. Each week, individuals would be asked to give progress reports, instituting a level of accountability for forward progress. We were also encouraged to bring our emerging research ideas or concerns to class meetings. As a class we soon built a strong, trusting rapport in which constructive criticism was the norm for discussion. The feedback from peers was extremely beneficial in crafting a better research project.

Beyond pushing each other to do quality research, we supported each other to overcome what seemed like insurmountable obstacles in the design and conduct of our respective studies. Participating in a class or seminar community of colleagues who are also engaged in research is a practice that I will continue to engage in because I learned that my own research could be improved both directly through discussion of my own agenda and indirectly through critique of others' research.

Communicating Research as a Clear Chain of Reasoning

Near the close of my research project I found myself asking questions that did not have easy answers, and that my advisor could not help me with. When do I stop analyzing my data? When do I know that I've spent enough

time interpreting my results? I needed to take a step back and think hard about whether or not I had answered my research questions, but also to think about the chain of reasoning that I was building. Inspired by Lesh, Lovitts and Kelly (2000), I have learned that the main links in a chain of reasoning for a research study include: (a) rationale for why the research is being conducted (b) identification of and justification of an appropriate lens or research framework that is used to determine relevant information and assumptions and (c) a clear articulation of what results are intended to be produced and for what purposes.

To answer my own questions, I needed to revisit the purpose of my study, the theoretical lenses I was using, and the results that I was analyzing. Specifically, I spent considerable time thinking hard about the research questions I set out to answer and the means by which I collected and analyzed my data. One mechanism that I found helpful to sort out these ideas was the preparation of a formal presentation and final paper. These outcomes of my pilot research forced me to be clear in communicating my chain of reasoning so that it made sense and could be followed by others. Giving a presentation to the department and writing a final paper for this course was not the end of my research, but instead, marked a healthy jumping off point that gave me a sense of accomplishment in looking to the future. Thus, a final lesson learned was the importance of taking time to carefully reflect on and clearly communicate research as a chain of reasoning.

Closing Comments

In closing, conducting an individual research project has provided a plethora of learning opportunities, more than I would have anticipated at the onset of the project. Some of the lessons I've learned involved working with the technicalities of the research system (including HSIRB), while other lessons were specific to developing good habits and practices as a researcher (including daily reading and writing).

Research can be both arduous and rewarding. The results of an individual research project will have a single author's name attached to them, but as a process, the design and conduct of research is never a solo endeavor. Acknowledgements are extended to the research participants, and those in my community—especially the well-intentioned skeptics and critics that continue to support and challenge me in new ways.

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